E-ISSN: 2618-0618
P-ISSN: 2618-060X

NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(1): 698-702
Received: 26-11-2025
Accepted: 31-12-2025

KN Rana
Assistant Professor, Department of Agronomy, College of Agriculture, Navsari Agricultural University, Bharuch, Gujarat, India

AP Patel
College of Agriculture, NAU, Waghai, Gujarat, India

Sonal Tripathi
Research Scientist (Soil Science), NAU, Navsari, Gujarat, India

MH Chavda
Assistant Professor, Department of Agronomy, COA, NAU, Bharuch, Gujarat, India

DM Chaudhari
Assistant Professor, Department of Agronomy, NMCA, NAU, Navsari, Gujarat, India

JM Kokani
Assistant Professor, Department of Agronomy, COA, NAU, Waghai, Gujarat, India

PK Waghmare
Assistant Professor, Department of Agronomy, VNMKV, Parbhani, Maharashtra, India

Corresponding Author:
KN Rana
Assistant Professor, Department of Agronomy, College of Agriculture, Navsari Agricultural University, Bharuch, Gujarat, India

Effect of direct seeded rice based intercropping system and source of organic inputs on nutrient uptake of crops and soil properties under rainfed condition

KN Rana, AP Patel, Sonal Tripathi, MH Chavda, DM Chaudhari, JM Kokani and PK Waghmare

DOI: https://www.doi.org/10.33545/2618060X.2026.v9.i1j.4768

Abstract
A field experiment entitled, "Effect of direct seeded rice based intercropping system and source of organic inputs on nutrient uptake of crops and soil properties under rainfed condition" was carried out during two consecutive kharif seasons of 2023 and 2024 on Clayey soil of Regional Rice Research Station, Navsari Agricultural University, Vyara, Dist. Tapi (Gujarat). The experiment was laid out in a randomized block design with factorial concept having three replications and fourteen treatment combinations consisting of two sources of organic inputs and seven intercropping systems. On pooled basis, the source of organic inputs fails to exert their significant effect on NPK content of grain as well as the straw of rice. Similarly, it also fails to exert their significant effect on NPK uptake of grain, straw, total uptake by biomass of rice and total uptake by intercropping system, except for the total N and K uptake in rice based intercropping system, where F_1: 100% RDN through FYM recorded significantly higher value. While assessing the effect of intercropping system, Nutrient content in grain and straw of rice was not significantly influenced by intercropping system. NPK uptake by grain, straw and total uptake by rice were significantly higher under sole rice, except the N uptake in rice grain. Total N and P uptake by intercropping system were significantly higher under sole soybean, while total K uptake under rice + groundnut intercropping system. Post-harvest soil fertility parameters remained unaffected due to the source of organic inputs and intercropping system.

Keywords: Direct seeded rice, intercropping systems, organic nutrient sources, nutrient uptake, soil fertility, rainfed condition

Introduction
Rice (*Oryza sativa* L.) is a premium food grain crop and is often the main source of calories and the principal food of millions of people. It has been referred as "Global Grain" because of its use as a prime staple food in about 100 countries of the world and provides staple food to more than half of the world's population. Asia is considered to be 'rice bowl' of the world and it produces and consumes more than 90 per cent of the world rice (Tyagi *et al.*, 2004). India ranks first in area and second in production. It also plays a pivotal role in Indian agriculture, is also considered as a major staple food for more than 70% Indian population. It is grown in all states and in all ecologies. Aerobic rice involves sowing dry seed into a prepared seedbed. In India, direct seeded aerobic rice production systems are rapidly replacing conventional rice production systems due to several advantages.
In India, rice covers the largest area of about 43.78 million hectares and producing 118.43 million tons with a productivity of 2705 kg/ha and extensively grown in most of states (Anonymous, 2020) [1]. West Bengal is the highest rice producing state in India followed by Utter Pradesh, Andhra Pradesh, Punjab, Tamil Nadu, Bihar, Chhattisgarh, Odisha, Assam, Karnataka and Gujarat. In Gujarat, most of the area under rice crop is confined in middle to south Gujarat about 9.06 lakh hectares area with the production of 21.47 lakh tons and productivity of 3269.7 kg/ha comprising the districts of Ahmedabad, Kheda, Anand, Vadodara, Dahod, Panchmahals, Surat, Valsad, Tapi, Dang and Navsari (Anonymous, 2021) [2].
Among the different sources of organic matter, farmyard manure (FYM) is considered the most

important for organic farming particularly in India because it is readily available on most farms, cost-effective, and well-suited to smallholder conditions where livestock and crop production are integrated. FYM provides a continuous and balanced supply of nutrients, improves soil structure and water holding capacity, and supports microbial activity, making it a reliable input for sustaining soil fertility under diverse Indian agro-climatic conditions. (Rajan *et al*., 2023) [11]. Jivamrit has gained prominence in organic and natural farming in India because it not only supplies nutrients but also acts as a powerful microbial inoculant that accelerates the decomposition of organic matter and enhances soil biological activity.

Intercropping means growing of two or more than two crops simultaneously on the same piece of land with specific planting geometry or in separate rows. The commonly used legumes for intercropping include Groundnut, Soybean, Green gram, Black gram, Pigeonpea, Cowpea, Clusterbean, *etc*. The potential of growing legumes in association with major staple food crops like rain fed rice could be substantially enhanced through intercropping. This will help to improve and maintain fertility of soil, ensuring efficient utilization of nutrients and to ensure economic utilization of land and capital (Jeyabal *et al*., 2001) [4]. It also allows efficient utilization of nutrients and ensuring economic utilization of land, labour and capital (Maingi *et al*., 2001) [6].

Materials and Methods

A field experiment was conducted at Regional Rice Research Station, Navsari Agricultural University, Vyara, Dist. Tapi (Gujarat) during the kharif seasons of 2023 and 2024, entitled with “Effect of direct seeded rice based intercropping system and source of organic inputs on nutrient uptake of crops and soil properties under rainfed condition”. Fourteen treatments comprising source of organic input along with intercropping systems *viz.*, F_1I_1: (100% RDN through FYM) + (rice sole crop), F_1I_2: (100% RDN through FYM) + (black gram sole crop), F_1I_3: (100% RDN through FYM) + (soybean sole crop), F_1I_4: (100% RDN through FYM) + (groundnut sole crop), F_1I_5: (100% RDN through FYM) + (4:1 rice + blackgram), F_1I_6: (100% RDN through FYM) + (4:1 rice + soybean), F_1I_7: (100% RDN through FYM) + (4:1 rice + groundnut), F_2I_1 : (50% RDN through FYM + 500 l/ha jivamrut) + (rice sole crop), F_2I_2: (50% RDN through FYM + 500 l/ha jivamrut) + (black gram sole crop), F_2I_3: (50% RDN through FYM + 500 l/ha jivamrut) + (soybean sole crop), F_2I_4: (50% RDN through FYM + 500 l/ha jivamrut) + (groundnut sole crop), F_2I_5: (50% RDN through FYM + 500 l/ha jivamrut) + (4:1 rice + blackgram), F_2I_6: (50% RDN through FYM + 500 l/ha jivamrut) + (4:1 rice + soybean), F_2I_7: (50% RDN through FYM + 500 l/ha jivamrut) + (4:1 rice + groundnut) were evaluated in randomized block design with factorial concept replicated thrice.

The experimental field was prepared by tractor ploughing followed by harrowing and planking to obtain a fine tilth. Furrows were opened and plots were laid out as per the experimental plan. Well-decomposed farmyard manure (FYM), derived from Surti buffalo, was applied 10-15 days before sowing according to the treatments and incorporated into the soil during bed preparation. The recommended dose of nitrogen was supplied through FYM on an equivalent nitrogen basis as per the recommended dose for rice. Jivamrut was applied as a drenching in soil at the time of sowing, 30 DAS and 60 DAS at a rate of 500 l/ha each, as per treatment combinations. Recommended spacing of 30 cm for rice and 30 × 10 cm for black gram, soybean, and groundnut was maintained. The rice variety GR-16 (Tapi) and the intercrops black gram (GU-3), soybean (KDS-344), and groundnut (GG-34) were sown at seed rates of 50, 15, 60, and 120 kg/ha, respectively. Seeds were sown in previously opened furrows at a depth of 5-6 cm and properly covered with soil.

The plant samples were analyzed for N, P and K content as per the standard methods. The concentration of nutrients in seed and stover were used to calculate the uptake of nutrients by rice and intercrops. The soil samples were collected from each net plot after harvest of groundnut crop at 0-15 cm depth. Organic carbon, available N and P_2O_5 and K_2O status of soil were analyzed by Walkely and Black’s method, Alkaline $KMnO_4$ method, Olsen’s method and Flame photometric method, respectively. The data were statistically analyzed for various characters as described by (Panse and Sukhatme, 1985) [14] experimentation and in pooled study.

Results and Discussion

Nutrient content and uptake (N, P and K) by rice grain and straw

The different sources of organic inputs did not exert any significant influence on the N, P and K content in rice grain and straw. Similarly, nutrient uptake by rice grain and straw (N, P and K) was also unaffected by organic input treatments.

The rice based intercropping systems had no significant impact on NPK content in both rice grain and straw. In terms of nutrient uptake, nitrogen uptake by rice grain was not significantly influenced by intercropping systems. However, phosphorus and potassium uptake by rice grain were significantly higher in the **I_1:** sole rice crop. For rice straw, N, P and K uptake were significantly higher under I_1, where in case of N uptake by straw, I_6: Rice + soybean (4:1) remained at par with **I_1**.

The interaction between sources of organic inputs and intercropping systems did not show any significant influence on the NPK content in grain or straw nor on nutrient uptake by rice grain and straw.

Total nutrient uptake (N, P and K) by rice

Sources of organic inputs did not significantly affect on total nutrient uptake of rice. Among intercropping systems, I_1: sole rice recorded the significantly highest total N and total P uptake of rice. Rice showed the lowest nutrient uptake when intercropped with blackgram. Potassium uptake was significantly higher under I_1: sole rice in 2024 and pooled analysis but showed no significant difference in 2023. The interaction effect between sources of organic inputs and intercropping systems were not significant for total N, P or K uptake across the years and pooled analysis.

The higher nutrient uptake in grain, straw and total uptake by rice under I_1: sole rice can be attributed to its higher plant population per unit area, which provides a greater sink size and higher nutrient demand and ultimately leading to increased uptake of N, P and K. This advantage of cereals in sole stands over intercrops is primarily due to greater root density and competitive ability for available resources (Jabbar *et al*). The beneficial effect observed with I_6: rice + soybean being statistically comparable to sole rice in N uptake may be due to the superior biological nitrogen fixation capacity of soybean and its partial transfer of nitrogen to rice in the intercropping system, as supported by Meena *et al*. (2018) [7] and Peoples *et al*. (2021) [10].

Total nutrient uptake (N, P and K) by rice based intercropping system

Effect of source of organic inputs: Among the sources of organic inputs, significantly higher total N and K uptake by intercropping system was recorded under F_1: 100% RDN through FYM, whereas P uptake also showed non-significant result.

This superiority of F_1 over F_2 can be attributed to the fact that FYM supplies a larger and more balanced quantity of primary nutrients directly to the soil, ensuring sustained availability of N, P and K throughout the crop growth period. The higher nutrient input from FYM also improves soil organic matter, microbial activity and cation exchange capacity, which in turn enhances nutrient mineralization and uptake efficiency of the crop. These results are consistent with Kusnarta *et al*. (2021) [5], Choudhary *et al*. (2022) [3] and Urmi *et al*. (2022) [13]

Effect of intercropping systems

Regarding intercropping systems, the highest total N uptake was observed in I_3: sole soybean, while the lowest was recorded in I_2: sole blackgram. A similar trend was noted for phosphorus uptake, with I_3 showing the highest values, statistically at par with I_4: sole groundnut and I_2 recording the lowest values. Discussing the overall nutrient dynamics of the intercropping system, the significantly higher total N and P uptake observed in I_3: soybean sole crop and I_4: groundnut sole crop can be attributed to their strong nitrogen fixing ability and greater biomass production compared to blackgram. Legumes establish symbiotic associations with rhizobium bacteria which fix atmospheric nitrogen into plant available forms and enrich both the host plant and the rhizosphere. Soybean is documented to fix the maximum amount of atmospheric nitrogen followed by groundnut, while blackgram contributes the least. This higher nitrogen input enhances vegetative growth, dry matter accumulation and root activity thereby improving the uptake of phosphorus and other nutrients.

In case of potassium uptake, I_7: rice + groundnut recorded the significantly higher values, at par with I_6: rice + soybean and **I_1:** sole rice, whereas I_2 again recorded the lowest uptake. The higher total K uptake under I_7: rice + groundnut, which was at par with I_6: rice + soybean and I_1: sole rice, may be attributed to root complementarity and efficient nutrient use in rice legume systems. Groundnut exploits deeper soil layers, while rice utilizes surface nutrients. Moreover, rice has a higher K uptake capacity, which contributes substantially to total system K uptake. Peoples *et al*. (2021) [10], Choudhary *et al*. (2022) [3], Mohan *et al*. (2023) [8] and Palmo *et al*. (2024) [9] also supported the present findings.

Interaction effect

The Interaction effect between sources of organic inputs and intercropping systems was found to be non-significant for total uptake of N, P and K across both years and in the pooled analysis.

Soil fertility status

The results about soil pH, electrical conductivity and organic carbon as well as available nitrogen, phosphorus and potassium showed that none of these soil parameters were significantly influenced by the sources of organic inputs, rice based intercropping systems and their Interaction effect.

Table 1: Nitrogen (N), phosphorus (P) and potash (K) content in grain and straw of rice as influenced by source of organic input and rice based intercropping systems

Treatment	N Content (%)		P Content (%)		K Content (%)	
	Grain	Straw	Grain	Straw	Grain	Straw
Source of organic input (F)						
F_1: 100% RDN through FYM	1.266	0.711	0.282	0.163	0.651	1.385
F_2: 50% RDN through FYM + 500 l/ha jivamrut	1.253	0.699	0.279	0.159	0.642	1.371
S.Em.±	0.033	0.011	0.006	0.002	0.007	0.020
C.D. at 5 %	NS	NS	NS	NS	NS	NS
Intercropping system (I)						
I_1: Rice sole crop	1.211	0.678	0.269	0.156	0.629	1.332
I_5: Rice + blackgram (4:1)	1.247	0.698	0.280	0.161	0.642	1.365
I_6: Rice + soybean (4:1)	1.318	0.735	0.290	0.165	0.665	1.431
I_7: Rice + groundnut (4:1)	1.261	0.710	0.285	0.162	0.651	1.384
S.Em.±	0.046	0.015	0.008	0.002	0.010	0.028
C.D. at 5 %	NS	NS	NS	NS	NS	NS
CV%	12.70	7.31	9.92	4.94	5.59	7.16

Table 2: Nitrogen (N), phosphorus (P) and potash (K) uptake in grain, straw and total uptake by rice as influenced by source of organic input and rice based intercropping systems

Treatment	N uptake (kg/ha)			P uptake (kg/ha)			K uptake (kg/ha)		
	Grain	Straw	Total uptake by rice	Grain	Straw	Total uptake by rice	Grain	Straw	Total uptake by rice
Source of organic input (F)									
F_1: 100% RDN through FYM	27.50	21.53	49.03	6.125	4.920	11.04	14.11	42.00	56.11
F_2: 50% RDN through FYM + 500 l/ha jivamrut	26.07	20.64	46.71	5.815	4.706	10.52	13.38	40.59	53.97
S.Em.±	0.84	0.56	1.01	0.166	0.120	0.20	0.29	1.25	1.26
C.D. at 5 %	NS	NS	NS	NS	NS	NS	NS	NS	NS
Intercropping system (I)									
I_1: Rice sole crop	29.40	23.75	53.14	6.520	5.467	11.99	15.27	46.82	62.09
I_5: Rice + blackgram (4:1)	24.98	19.43	44.41	5.589	4.492	10.08	12.82	38.18	51.00
I_6: Rice + soybean (4:1)	27.26	21.06	48.33	6.006	4.719	10.72	13.74	41.01	54.75
I_7: Rice + groundnut (4:1)	25.50	20.09	45.59	5.764	4.575	10.34	13.16	39.18	52.34
S.Em.±	1.19	0.79	1.43	0.234	0.169	0.28	0.41	1.77	1.78
C.D. at 5 %	NS	2.30	4.14	0.678	0.490	0.82	1.19	5.12	5.17
CV%	15.34	13.05	10.33	13.59	12.18	9.08	10.35	14.84	11.23

Table 3: Total uptake of nitrogen (N), phosphorus (P) and potash (K) by intercropping systems as influenced by source of organic input and rice based intercropping systems

Treatment	Total N uptake by intercropping system (kg/ha)	Total P uptake by intercropping system (kg/ha)	Total K uptake by intercropping system (kg/ha)
Source of organic input (F)			
F_1: 100% RDN through FYM	84.27	13.41	52.99
F_2: 50% RDN through FYM + 500 l/ha jivamrut	78.81	12.56	50.27
S.Em.±	1.17	0.17	0.74
C.D. at 5 %	3.31	NS	2.11
Intercropping system (I)			
I_1: Rice sole crop	53.14	11.99	62.09
I_2: Blackgram sole crop	48.67	5.70	23.14
I_3: Soybean sole crop	154.59	17.47	40.47
I_4: Groundnut sole crop	116.78	17.11	54.77
I_5: Rice + blackgram (4:1)	52.16	10.98	54.96
I_6: Rice + soybean (4:1)	77.31	14.04	62.68
I_7: Rice + groundnut (4:1)	68.10	13.58	63.29
S.Em.±	2.18	0.32	1.39
C.D. at 5 %	6.20	0.91	3.94
CV%	9.28	8.53	9.33

Table 4: Grain/seed yield (kg/ha) and Straw/haulm yield (kg/ha) of intercropping system as influenced by source of organic inputs and rice based intercropping systems.

Treatments	Grain/seed yield (kg/ha)		Straw/haulm yield (kg/ha)	
	Rice	Intercrop	Rice	Intercrop
F_1I_1: (100% RDN through FYM) + (Rice sole crop)	2460	-	3548	-
F_1I_2: (100% RDN through FYM) + (Black gram sole crop)	-	756	-	1082
F_1I_3: (100% RDN through FYM) + (Soybean sole crop)	-	2075	-	2166
F_1I_4: (100% RDN through FYM) + (Groundnut sole crop)	-	1628	-	3181
F_1I_5: (100% RDN through FYM) + (4:1 Rice + blackgram)	2048	127	2819	237
F_1I_6: (100% RDN through FYM) + (4:1 Rice + soybean)	2113	405	2900	485
F_1I_7: (100% RDN through FYM) + (4:1 Rice + groundnut)	2059	314	2872	716
F_2I_1: (50% RDN through FYM + 500 lit/ha jivamrut) + (Rice sole crop)	2400	-	3454	-
F_2I_2: (50% RDN through FYM + 500 lit/ha jivamrut) + (Black gram sole crop)	-	716	-	1053
F_2I_3: (50% RDN through FYM + 500 lit/ha jivamrut) + (Soybean sole crop)	-	1984	-	2057
F_2I_4: (50% RDN through FYM + 500 lit/ha jivamrut) + (Groundnut sole crop)	-	1553	-	3095
F_2I_5: (50% RDN through FYM + 500 lit/ha jivamrut) + (4:1 Rice + blackgram)	1946	111	2764	170
F_2I_6: (50% RDN through FYM + 500 lit/ha jivamrut) + (4:1 Rice + soybean)	2018	362	2831	429
F_2I_7: (50% RDN through FYM + 500 lit/ha jivamrut) + (4:1 Rice + groundnut)	1988	280	2790	631

Table 5: Effect of different source of organic input and intercropping systems on post-harvest soil pH, EC and OC, available nitrogen, available phosphorus and available potash

Treatment	Soil pH	Soil EC (dS/m)	Soil OC (%)	Available nitrogen (kg/ha)	Available phosphorus (kg/ha)	Available potash (kg/ha)
Source of organic input (F)						
F_1: 100% RDN through FYM	7.22	0.141	0.821	333.37	35.26	337.33
F_2: 50% RDN through FYM + 500 l/ha jivamrut	7.31	0.141	0.799	328.52	34.50	329.91
S.Em.±	0.05	0.002	0.007	2.84	0.41	2.85
C.D. at 5 %	NS	NS	NS	NS	NS	NS
Intercropping system (I)						
I_1: Rice Sole crop	7.41	0.142	0.775	323.74	32.76	322.82
I_2: Blackgram Sole crop	7.20	0.135	0.824	333.63	35.90	337.87
I_3: Soybean Sole crop	7.23	0.146	0.841	337.34	36.83	343.45
I_4: Groundnut Sole crop	7.30	0.142	0.832	335.35	36.53	340.23
I_5: Rice + blackgram (4:1)	7.27	0.139	0.786	326.27	33.33	326.50
I_6: Rice + Soybean (4:1)	7.20	0.142	0.813	331.44	34.93	333.89
I_7: Rice + groundnut (4:1)	7.28	0.141	0.799	328.88	33.87	330.59
S.Em.±	0.10	0.003	0.013	5.32	0.77	5.32
C.D. at 5 %	NS	NS	NS	NS	NS	NS
CV%	4.57	7.02	5.45	5.57	7.60	5.53

References

1. Anonymous. Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Government of India; 2020.
2. Anonymous. Area, production and productivity. Directorate of Agriculture, Government of Gujarat; 2021.
3. Choudhary R, Kumar R, Sharma GD, Sharma RP, Rana N, Dev P. Effect of natural farming on yield performance, soil health and nutrient uptake in wheat + gram intercropping system in sub-temperate regions of Himachal Pradesh.

Journal of Crop and Weed. 2022;18(2):1-8.
4. Jeyabal A, Kuppuswamy G. Recycling of organic wastes for the production of vermicompost and its response in rice-legume cropping systems and soil fertility. Heriana Journal of Agronomy. 2001;15(3):153-170.
5. Kusnarta IGM, Rahmadhanti D, Dulur NWD, Wangiyana W. Soil chemical characteristics and yield of red rice under aerobic irrigation system as affected by intercropping with peanut and application of organic wastes on permanent raised beds. IOP Conference Series: Earth and Environmental Science. 2021;913(1):1-6.
6. Maingi MJ, Shisanya AC, Gitonga MN, Hornetz B. Nitrogen fixation by common bean in pure and mixed stands in semi-arid South East Kenya. European Journal of Agronomy. 2001;14:319-334.
7. Meena RS, Vijayakumar V, Yadav GS, Mitran T. Response and interaction of *Bradyrhizobium japonicum* and arbuscular mycorrhizal fungi in the soybean rhizosphere. Plant Growth Regulation. 2018;84(2):207-223.
8. Mohan G, Gohain T, Tzudir L, Singh AP, Nongmaithem D. Study on yield, nutrient content and nutrient uptake of rice-based intercropping system as influenced by integrated nutrient management. Biological Forum - An International Journal. 2023;15(7):141-146.
9. Palmo T, Singh L, Masood A, Saad AA, Kanth RH, Saxena A, Chesti MH, Mir AH, Wani FJ. Nutrient uptake of maize as influenced by intercropping with different genotypes of groundnut under temperate Kashmir Valley. Journal of Advances in Biology & Biotechnology. 2024;27(4):171-176.
10. Peoples MB, Giller KE, Jensen ES, Herridge DF. Quantifying country- to global-scale nitrogen fixation for grain legumes: I. Reliance on nitrogen fixation of soybean, groundnut and pulses. Plant and Soil. 2021;469:1-14.
11. Rajan B, Naresh RK, Himanshu T, Singh PK, Dhritiman D, Manoj K, Banik R, Tomar G. Farmyard manure as a resource for integrated nutrient management. The Pharma Innovation Journal. 2023;12(4):672-681.
12. Tyagi AK, Khurana JP, Khurana AP, Raghubanshi S, Gour A, Kapur A, Sharma S. Structural and functional analysis of rice genome. Journal of Genetics. 2004;83:79-99.
13. Urmi TA, Biswas JC, Rahman MA, Haque MM, Akter S, Zaman MS. Integrated nutrient management for rice yield, nutrient use efficiency and soil fertility. Agronomy. 2022;12(1):182.
14. Panse M, Block HU, Föster W, Mest HJ. An improved malondialdehyde assay for estimation of thromboxane synthase activity in washed human blood platelets. Prostaglandins. 1985 Dec 1;30(6):1031-40.